



NASA Electronic Procedure Technology

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Autonomy Panel

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Long Beach California



Background – Mission Operation Overview

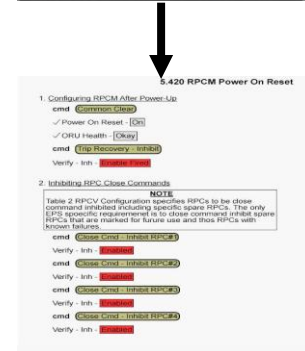


- Crew operate equipment using *procedures*
- Mission Control staff operate equipment remotely using *procedures*
- Mission Control staff maintain operations using *schedules and plans*
- Staffing, equipment configuration and manifests also require scheduling and planning

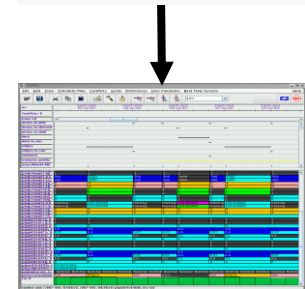
Hardware



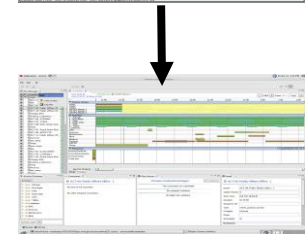
Procedure



Schedule

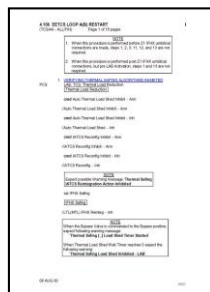
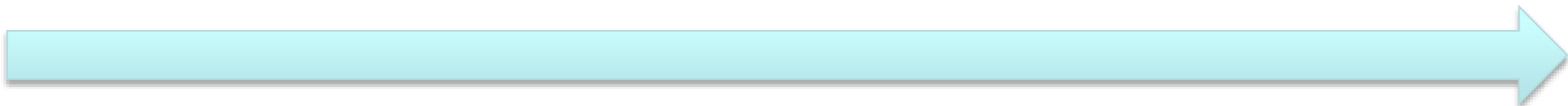
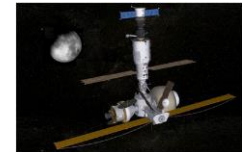
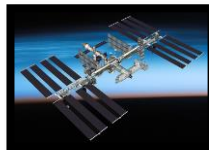


Plan





Evolution of Procedures

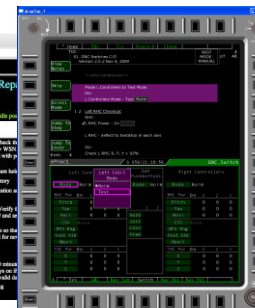


Early ISS—PDF



Orion; Enhanced XML (PRL)

- Computer Oversight
- Automation



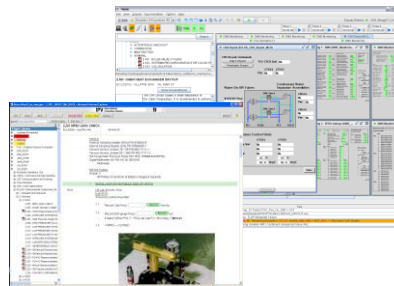
Deep Space Exploration- AR-eProc;

- PRL Extension
- Machine Vision and Marker-less Registration

Apollo & Space Shuttle—Paper

Current ISS—IPV/XML

- No Automation or Computer Oversight





So, What is Procedures?



Flight Procedure



- Procedures are used to conduct any complex operation
- Procedures contain knowledge about how to operate systems to achieve mission goals / tasks
- Procedures are the approved means by which a user operates a system
- Users of procedures include crew, flight controllers, instructors, mission designers, payload community, etc.

5.420 RPCM POWER ON RESET

(GND SYSTEMS/X2R4 - 12A/FIN 4) Page 1 of 14 pages

1. CONFIGURING RPCM AFTER POWER-UP

Reference Table 1 for Element RPCM Architecture

Record Element and RPCM from Table 1

Element = _____

RPCM [X] = _____

PCS

Element: EPS

Element: EPS

sel RPCM [X] where [X] is selected from Table 1

RPCM X

sel Firmware

'Clear Cmds'

cmd Common Clear

vPower On Reset – blank

vORU Health – OK

RPCM X

sel Input Undervoltage

cmd Trip Recovery – Inhibit Arm

cmd Trip Recovery – Inhibit (Verify – Inh)

2. INHIBITING RPC CLOSE COMMANDS

NOTE

Table 2 RPC Configuration specifies RPCs to be close command inhibited including specific spare RPCs. The only EPS specific requirement is to close command inhibit spare RPCs that are marked for future use and those RPCs with known failures.

Refer to Table 2 for RPC Configuration.

Record RPCs which require Close Inhibits from Table 2.

RPCM [X] = _____

Close – Inhibit RPC [Y] = _____

Element: EPS

Element: EPS



Procedure Requirements



- ***Need support for automating procedure execution***
 - Commands and telemetry
 - Safety conditions/context
 - Explicit control structures
- ***Don't want to lose human readability***
 - Capturing “look-and-feel” of current procedures
 - Presentation of procedure content in a human-friendly way
- ***Interleave human actions with automated scripts***
- ***Integrate multimodal interfaces to enhance user performance by providing***
 - Context sensitive cues
 - On-demand real-time assistant
- ***Use Procedure Representation Language***
 - Capture and formalized the above stated requirements
 - Started from NASA Onboard Data File standards and construct support automation



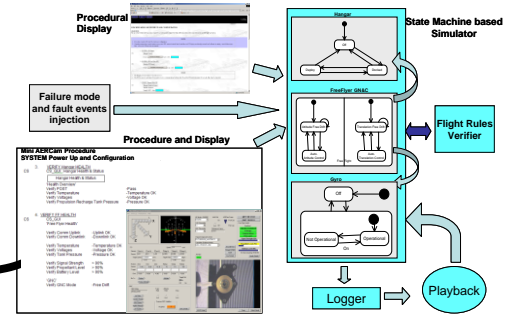
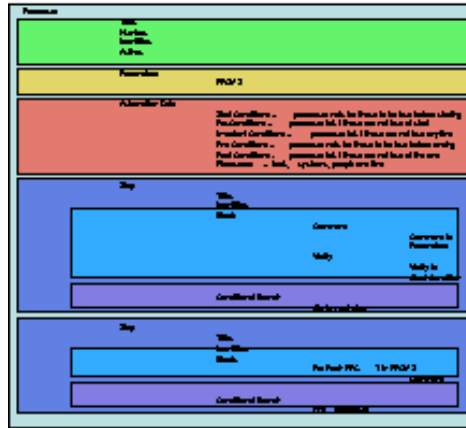
Uses of PRL



Procedure Representation Language (PRL) file



Procedure Authoring Tool (PAT)

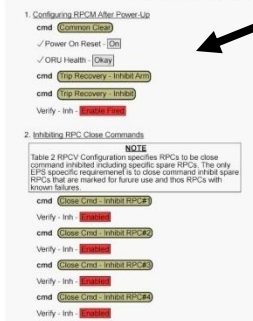


Procedure Verification Tools

Paper Procedure



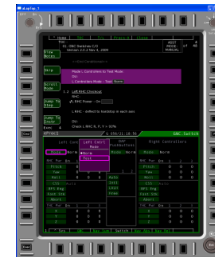
Procedure Displays



Translator

Send
Command foo
Command bar
Wait 10 secs
Command foo2

Ground Control Tools (e.g., Thin Layer)



Orion eProc (RPL XML)



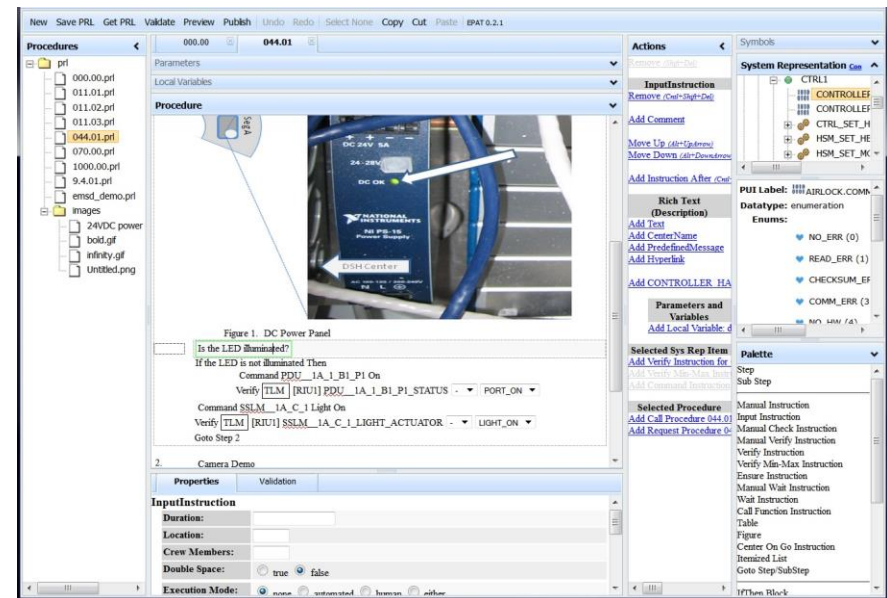
AR Authoring



Advanced Procedure Authoring Tool

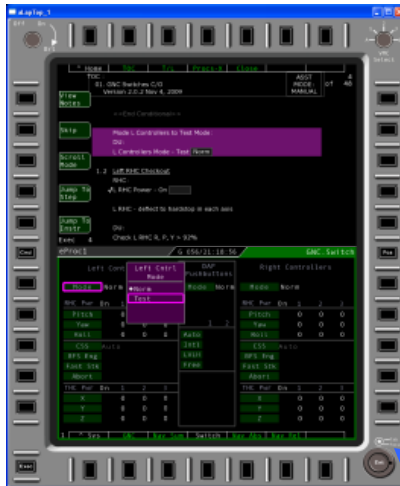


- Full PRL features
- Full PRL compliant
- Drag-n-drop user interface
- Leverage on web based & html5 technologies
- Benefits
 - No executable download or plug-in installation require
 - Centralized application deployment
 - More robust media support from html5 better integration editing, viewing and execution





Procedure Viewer & Executor



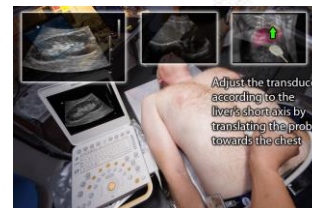
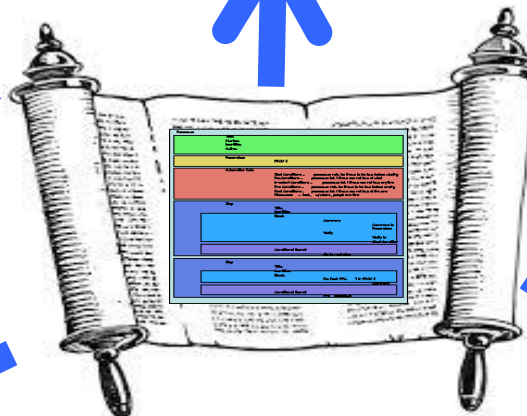
Orion eProc-Flight Deck – focus on Edge Keys Display & Keyboard-less interaction



WebPD – Focus on C&W Integration



AR-eProc– Focus on mixed reality interaction with tablet device



TOCA Buffer Changeout Proc.
Step 1 - Cover Removal
Step 2 - QD Disconnect
Step 3 - Buffer Removal
Step 4 - Buffer Replacement
30 days ago

WARNING Remove lid of container slowly, as contents are under pressure and could burst!
30 days ago

Google Glass – Focus on Mobility & mobile interactions



AR-eProc– Focus on mixed reality interaction hands-free operation

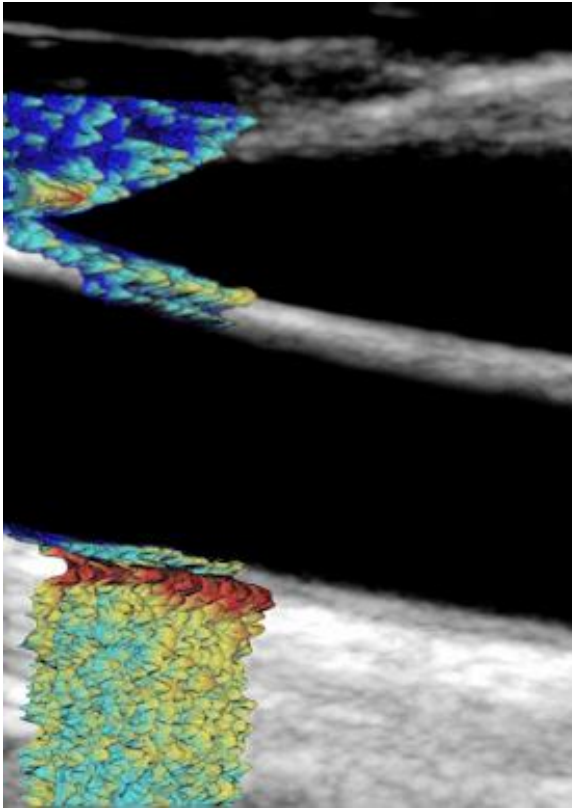
Capture Rich Procedure Content Once and Use It Everywhere!!



What's next?



Future Direction: Autonomous Ultrasound Ops.



1. Image detection software depiction of anatomical landmarks which define an adequate carotid image superimposed over an actual carotid artery ultrasound image



2. Robonaut 2 being remotely guided through carotid artery ultrasound imaging technique



Challenges / Needs



- ***Reliable Machine Vision system to work in an unstructured environment using a mobile glasses device***
 - Object recognition under occlusion
 - Robust Object tracking
 - Computing architecture
- ***Data Fusion***
 - Health Sensors integration
 - System telemetry monitoring and commanding
- ***Simplify Augmented Reality Authoring and Procedure Content Management***
 - Automate the 3D model creation
 - Simply workflow to associate AR content to procedure instructions



Backup



Augmented Reality Electronic Procedures for JITT “Pinnable”

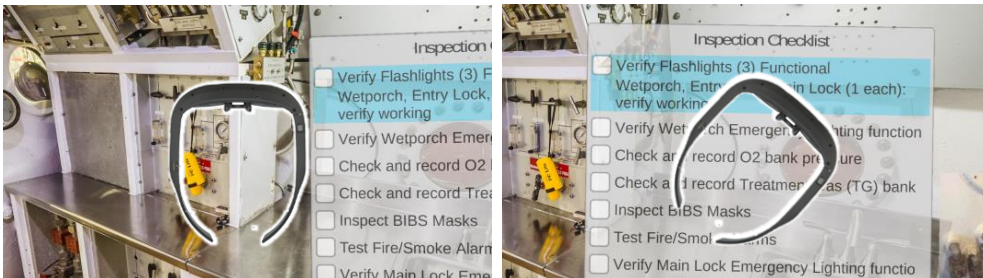
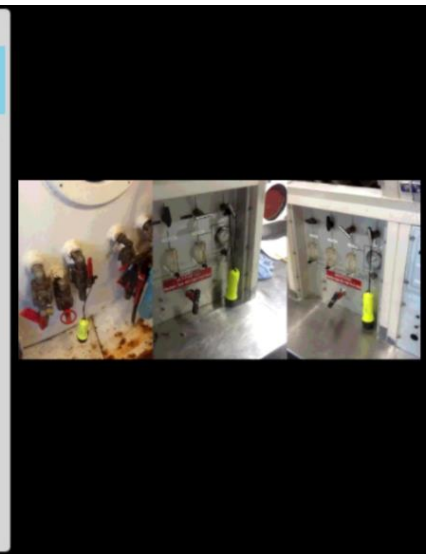


“Pinnable Procedures” Introduction

- Procedures designed to be an intuitive blend of text, still photos
- Quick “reminder” checklist
- Procedure can be moved and kept out of the direct worksite, yet accessible at a glance
- Wearable headset (ODG Glasses R-6)



Inspection Checklist	
<input type="checkbox"/>	Verify Flashlights (3) Functional Wetporch, Entry Lock, Main Lock (1 each): verify working
<input type="checkbox"/>	Verify Wetporch Emergency Lighting function
<input type="checkbox"/>	Check and record O2 bank pressure
<input type="checkbox"/>	Check and record Treatment Gas (TG) bank
<input type="checkbox"/>	Inspect BIBS Masks
<input type="checkbox"/>	Test Fire/Smoke Alarms
<input type="checkbox"/>	Verify Main Lock Emergency Lighting function
<input type="checkbox"/>	Inspect Pony Bottles (9)
<input type="checkbox"/>	Inspect O2 Cylinders (2)
<input type="checkbox"/>	Test CO Alarm



- Active step expands, showing additional information
- Check steps as complete
- Images provide additional context

Return

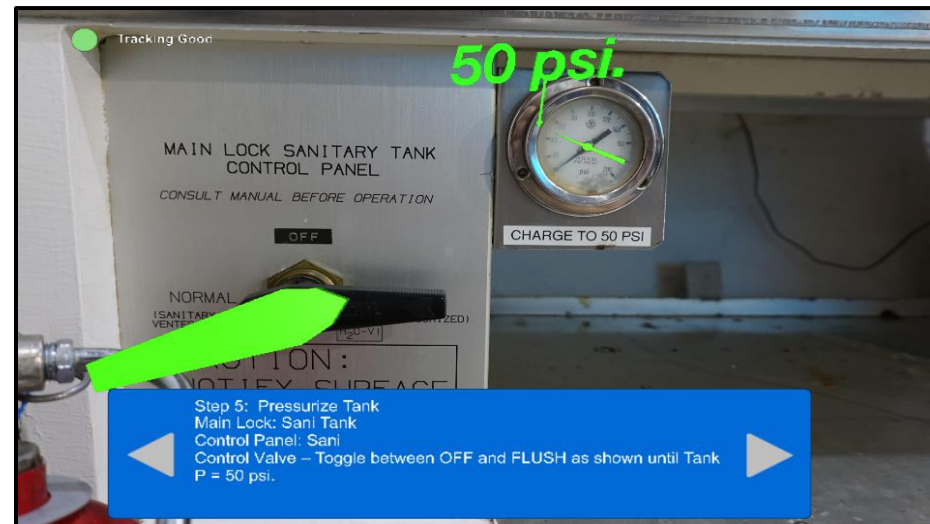


Augmented Reality Electronic Procedures for JITT “Marker-less”



“Augmented Reality Electronic Procedures” Introduction

- Step by step guidance reduces need for prior training
- Complex tasks are broken into a series of simpler guided steps
- Procedures provide context sensitive animations on top of the real world workspace



Return

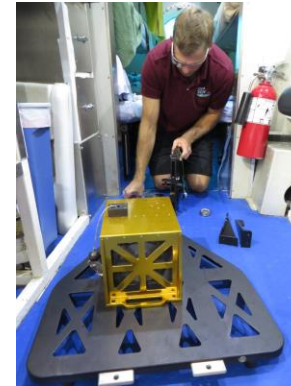


SEATEST II: Just-in-time training & procedure execution with Glass



Miniature Exercise Device (MED):

- a. Equipment Assembly Task
- b. Equipment Dis-Assembly Task



Just-in-time (JIT) training of a Sani-tank purge

After the task was completed using the Google Glass – the same JITT material was viewed on an iPad



Return

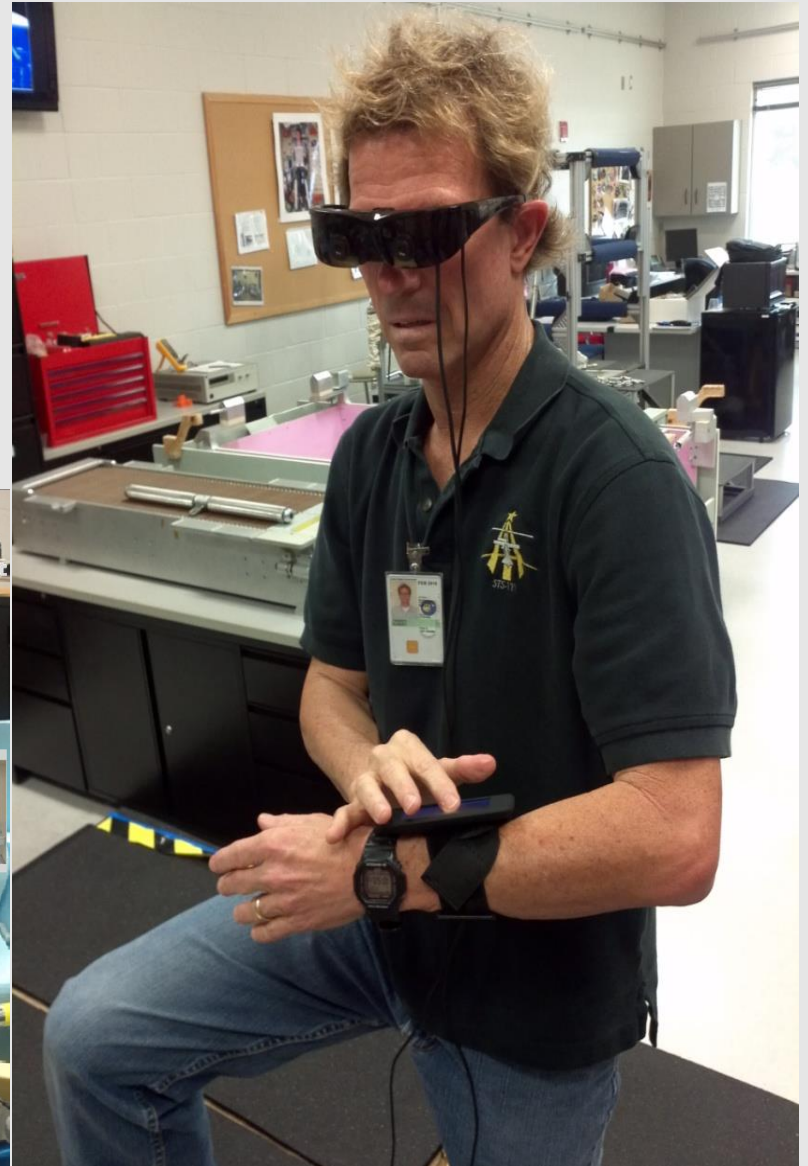
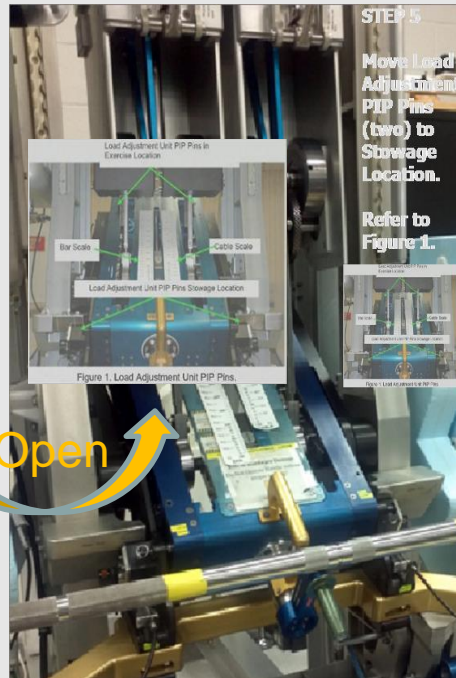
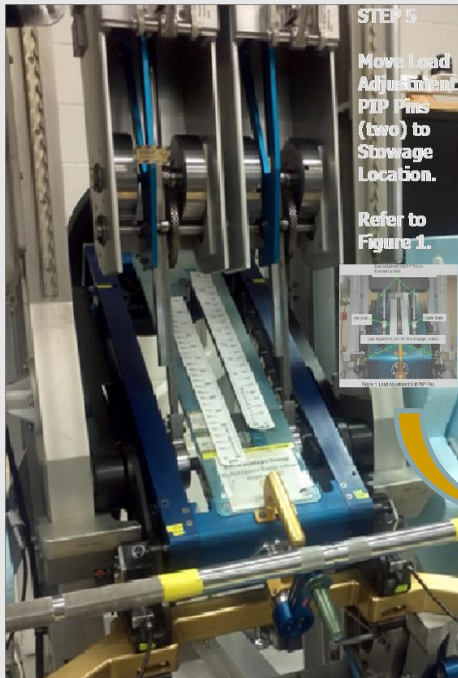
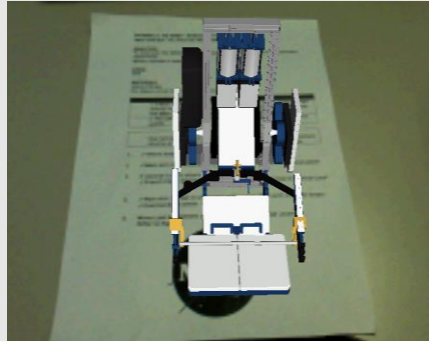


Augmented Reality to Enhance Crew Medical Training





Augmented Reality (AR-eProc ARED)





Augmented Reality (AR-eProc TOCA)



Return



Orion Electronic Procedures



Orion Electronic Procedures Interface Screenshot

Top Panel: Includes a brightness control knob (Off/On/Brt), a VMC Select knob (1/2/3), and a row of indicator lights.

Navigation Bar: Buttons for ^ Home, TOC, T/L, Procs, and a page indicator (2 of 68).

Procedure List:

- 2 ^ Home
- Procs INIT
- Open-1 TOC
- View [NR]
- 1. APDS Power
- X cb Ess 1BC / Main B Sys 1 - CI
- Skip cb Ess 1BC / Main B Vst Depr Isol 1 - CI
- Scroll Mode
- Jump To Step
- Jump To Instr
- Close Proc

Diagram Section:

eProc1 G 263/14:34:58 APDS Power

10 ^ Sys APDSPow APDSDck APDSPma SPEC167

Bottom Panel: Includes an Exec button, a row of indicator lights, and an Ent button.

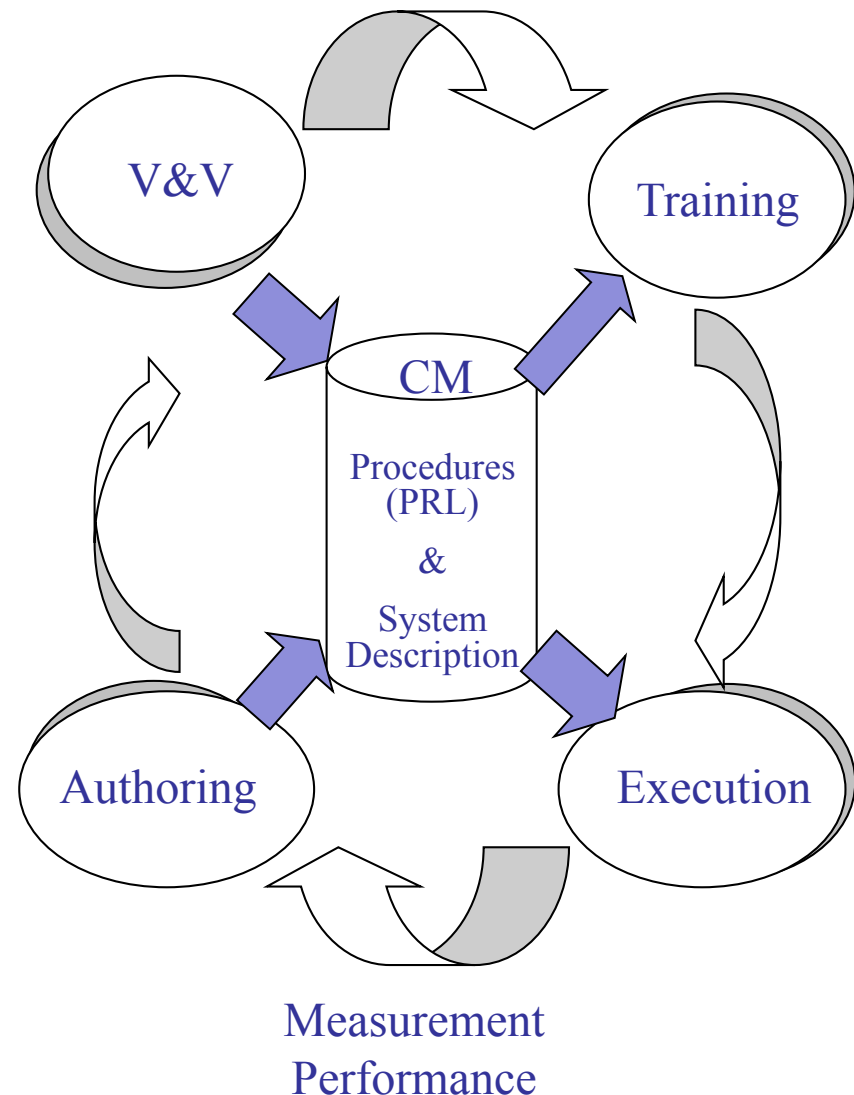
Return



Procedure Lifecycle Development



- **Procedure Authoring Tool (PAT)**
 - Procedure authors currently use IPV (Licensed software & not easy to use)
 - Need an easy-to-use authoring environment
 - Need an easy method to add telemetry & commands
- **Procedure verification & validation (PV)**
 - Procedure verifiers are human intensive
 - Need for desktop verification tools to catch simple mistakes
- **Procedure Library Admin. (PLA)**
 - Configuration control works reasonably well today
 - Need to be integrated with Procedure Repository and Procedure approval system
- **Procedure Viewer/Executor (PVE)**
 - Integration with crew time and Caution & Warning system
 - Need to view/execute/track anywhere and any configuration (stationary, mobile, hand-free. Etc.)
- **Procedure training**
 - Integration with Workflow CR and procedure verification and validation
 - Measure and track performance





System Representation



- Procedure language describes how to operate any system. They do not describe the system itself
- System representation needs to define
 - Telemetry
 - Commands and command parameters
 - System hierarchy and classes
 - e.g., commanding the Orion Display Pages
- Must be available during procedure editing, validation and execution
- We selected XML Telemetric & Command Exchange (XTCE) -- an industry and NASA standard



Procedure Log Preferences

Recommended

...

Active

5.10(1) Ultrasound - Kidney Scan

Completed

...

TOC

2.01 T61P Device Changeout

2.02 Hard Drive Not Functioning

2.1a T61P Device Changeout Without Unstow

2.1b T61P Device Changeout Without Unstow Or Stow

2.2a Power On and Login To Laptop

3.01 Atrium H2O Resupply - Main

3.02 Atrium H2O Resupply - Aux

3.03 Terminate Atrium H2O Resupply

3.04 Atrium Main Transfer - Flow High

3.05 Atrium Aux Transfer - Flow High

3.06 Atrium H2O Resupply With A3 Failed High

3.07 Atrium Main Transfer - Flow Low

3.08 Atrium Aux Transfer - Flow Low

4.01 Filter Changeout

4.02 IRED Canister Inspection and Cleaning

5.01 Calf and Bicep Muscle Atrophy and Pain

5.02 SLM Measurement

5.03 Ultrasound - Configure CX50 Unit

5.04 Ultrasound - Appendicitis Scan

5.05 Examination - Abdominal Pain

5.06 Genitourinary Anatomy

5.07 Treating Pain

5.08 Vital Signs

5.09 Genitourinary Procedure - Urine Retention and

5.10 Ultrasound - Kidney Scan

5.11 Ultrasound - Gallbladder Scan

5.12 Ultrasound - Bladder Scan

6.01 Sample Transfer

6.02 Plant Soil pH Determination

7.01 24 VDC Power Supply LED Check

7.02 28 VDC Power Supply Check

7.03 Wireless Sensor Node Off Line

7.04 cRIO 1 9477 Card Off Line

7.05 28 V Power Supply Failed

7.06 cRIO 1 Off Line

7.07 24 V Power Supply Off Line

8.01 DSH Back Side Camera Survey

2.0.106 EXAM - PERIODIC HEALTH EVALUATION

5.10(1) Ultrasound - Kidney Scan

Start Stop

Objective:
To acquire images and measurements of the patient's right and left kidney.

PARTS:

- Ultrasound CX50
- Ultrasound Probe - C5-1
- - Probe Scanhead Cover
- - Probe Connector Cover
- - Reference Documents
- - Keyboard and Probe Placement Cue Card
- Ultrasound Echo Gel (one bottle)
- Dry Wipes

U 1 CONFIGURE CX50 ULTRASOUND DEVICE

NOTE


- The body has two kidneys and they are not always symmetrical in shape or position. As a result the operator will have to image and measure both kidneys. The right kidney is usually lower in the body by 1-2 inches and is easier to find.
- Supine position (lying down) is preferred for the patient and they can roll to the right and left for the right and left kidneys, respectively.

U 1.1 Configure the CX50 Ultrasound Device with the C5-1 probe using procedure "5.3 Ultrasound - Configure CX50 Device"

Done Submit

U 1.2 For "Preset" on the CX50, select "Abd Renal"

U 1.3 The gel should be applied to applied and resemble what is seen in Figure 1.



U 2 SCANNING PROCEDURE

U 2.1 Expose the patient's abdomen.



WebPD - Automation



10.02(1) Light Test - Mozilla Firefox

File Edit View History Bookmarks Tools Help

10.02(1) Light Test +

localhost:8080/webpd/ ☆ Google

Procedure Preferences

Recommended

Active

10.02(1) Light Test

Completed

TOC

- 1234 Drive PTZ Camera
- CCPT Control Center Pre-Test Setup
- Fuel LCH4 Fill
- LOW_P Low Press Leak Check
- LOX LOX Fill
- PF Pre-Fill Checklist
- PwrUp Morpheus Power Up
- dsh
- 10.0_Normal_Operating
 - 10.01 Set Controllers to Operating
 - 10.02 Light Test**
 - 10.02a Light One

10.02(1) Light Test

Start Stop

Objective:
Turn all 8 PDU ports on Bank 1 ON, check that they are turned ON, turn all 8 lights ON, check that they are turned ON, turn all 8 lights OFF, check they are all turned OFF, turn all 8 PDU ports on Bank 1 OFF, check that they are turned OFF.

C 1 Turn On PDU Ports for Lights Yes

- A 1.1 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.2 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.3 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.4 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.5 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.6 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.7 cmd [RIU1] POWER_PDU_PORT_ON_CMD
- A 1.8 cmd [RIU1] POWER_PDU_PORT_ON_CMD

C 2 Check PDU Ports Are On Enter this step? Yes Submit

- A 2.1 verify [RIU1] POWER_PDU_BANK1_PORT1_ACTUATOR PORT_ON
- A 2.2 verify [RIU1] POWER_PDU_BANK1_PORT2_ACTUATOR PORT_ON
- A 2.3 verify [RIU1] POWER_PDU_BANK1_PORT3_ACTUATOR PORT_ON
- A 2.4 verify [RIU1] POWER_PDU_BANK1_PORT4_ACTUATOR PORT_ON
- A 2.5 verify [RIU1] POWER_PDU_BANK1_PORT5_ACTUATOR PORT_ON
- A 2.6 verify [RIU1] POWER_PDU_BANK1_PORT6_ACTUATOR PORT_ON
- A 2.7 verify [RIU1] POWER_PDU_BANK1_PORT7_ACTUATOR PORT_ON
- A 2.8 verify [RIU1] POWER_PDU_BANK1_PORT8_ACTUATOR PORT_ON



WebPD – Adding Image Notes



[phe]Periodic Health Examination

File Settings Views User DR APS

Active Procedures

phe Periodic Health Examination

Completed Procedures

Table of Contents

- 1234 Drive P12 Control
- 1 Landing Test
- CCPT Control Center P
- Fuel LCH4 Fill
- LOW_P Low Press Lea
- LOX LOX Fill
- 3.PF Pre-Fill Checklist
- PTZ_CAM02__1H_T_1
- PwrUp Morpheus Pow
- 1.PADPF Pad Pre-Fligh
- 1 Periodic Health Exam**
- 1 SequenceMaster

[phe]Periodic Health Examination

Start Stop Close

Periodic Health Examination

Objective: Perform a general health examination

1 Collect Patient Vitals

1.1 [CMO] Enter Temperature (F) 99.6

1.2 [CMO] Enter Blood Pressure 122/84

1.3 [CMO] Enter Pulse 56

1.4 [CMO] Enter Pulse Oximetry 48

1.5 [CMO] Enter Respiratory Rate 52

1.6 [CMO] Submit Vitals Done

2 Skin Examination

2.1 [CMO] Launch Webcam Controller. Add Note Done Skip

2.2 [CMO] Using webcam to document any rash, injury or other ailments that have developed Take Picture



WebPD – Adding Text Notes



[phe]Periodic Health Examination

File Settings Views User DR APS

Active Procedures

phe Periodic Health Examination

Completed Procedures

Table of Contents

- 1254 Drive File Camera
- 1 Landing Test
- CCPT Control Center P
- Fuel LCH4 Fill
- LOW_P Low Press Lea
- LOX LOX Fill
- 3.PF Pre-Fill Checklist
- PTZ_CAM02__1H_T_1
- PwrUp Morpheus Pow
- 1.PADPF Pad Pre-Fligh
- 1 Periodic Health Exam**
- 1 SequenceMaster

[phe]Periodic Health Examination

Start Stop Close

Periodic Health Examination

Objective: Perform a general health examination

1 Collect Patient Vitals

1.1 [CMO] Enter Temperature (F)	99.6
1.2 [CMO] Enter Blood Pressure	122/84
1.3 [CMO] Enter Pulse	56
1.4 [CMO] Enter Pulse Oximetry	48
1.5 [CMO] Enter Respiratory Rate	52
1.6 [CMO] Submit Vitals	Done

2 Skin Examination

2.1 [CMO] Launch Webcam Controller. Done Skip

2.2 [CMO] Using webcam to document any rash, injury or other ailments that have developed

Go To Strike Add Note Take Picture



WebPD - IM



File Settings Views User DR

Active Procedures

phe Periodic Health Examination

Completed Procedures

Table of Contents

- 1 Landing Test
- CCPT Control Center P
- Fuel LCH4 Fill
- LOW_P Low Press Lea
- LOX LOX Fill
- 3.PF Pre-Fill Checklist
- PTZ_CAM02__1H_T_1
- PwrUp Morpheus Pow
- 1.PADPF Pad Pre-Fligh
- 1 Periodic Health Exam**
- 1 SequenceMaster

[phe]Periodic Health Examination

Start Stop

Periodic Health Examination

Objective: Perform a general health examination

1 Collect Patient Vitals

1.1 [CMO] Enter Temperature (F)

99.6

1.2 [CMO] Enter Blood Pressure

122/84

1.3 [CMO] Enter Pulse

56

1.4 [CMO] Enter Pulse Oximetry

48

1.5 [CMO] Enter Respiratory Rate

52

1.6 [CMO] Submit Vitals

Done

2 Skin Examination

2.1 [CMO] Launch Webcam Controller.

Done Skip

2.2 [CMO] Using webcam to document any rash, injury or other ailments that have developed

Compose

Messages

[ALHAT] 12:47:45 PM

I am reviewing your images now.

Return